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(12) United States Patent
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(45) Date of Patent: Jul. 10, 2007

- (54) METHODS FOR PRODUCING LOW STRESS POROUS LOW-K DIELECTRIC MATERIALS USING PRECURSORS WITH ORGANIC FUNCTIONAL GROUPS**

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(Continued)

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- (*) Notice:**
- Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 113 days.

U.S. Office Action mailed May 31, 2006, from U.S. Appl. No. 10/941,502.

(Continued)

- (21) Appl. No.: 10/927,777**

Primary Examiner—M. Wilczewski

- (22) Filed: Aug. 27, 2004**

(74) Attorney, Agent, or Firm—Beyer Weaver LLP**Related U.S. Application Data****(57)****ABSTRACT**

- (63) Continuation-in-part of application No. 10/672,311, filed on Sep. 26, 2003, which is a continuation-in-part of application No. 10/404,593, filed on Mar. 31, 2003.**

Methods of preparing a low stress porous low-k dielectric material on a substrate are provided. The methods involve the use of a structure former precursor and/or porogen precursor with one or more organic functional groups. In some cases, the structure former precursor has carbon-carbon double or triple bonds. In other cases, one or both of the structure former precursor and porogen precursor has one or more bulky organic groups. In other cases, the structure former precursor has carbon-carbon double or triple bonds and one or both of the structure former precursor and porogen precursor has one or more bulky organic groups. Once the precursor film is formed, the porogen is removed, leaving a porous low-k dielectric matrix with high mechanical strength. Different types of structure former precursors and porogen precursors are described. The resulting low stress low-k porous film may be used as a low-k dielectric film in integrated circuit manufacturing applications.

- (51) Int. Cl.**

H01L 21/31 (2006.01)
H01L 21/469 (2006.01)
C23C 16/40 (2006.01)
C23C 16/56 (2006.01)

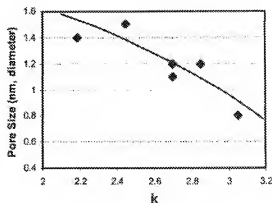
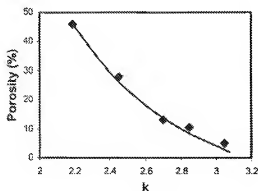
- (52) U.S. Cl.**
- 438/781; 438/789; 438/790; 427/557

- (58) Field of Classification Search**
- 427/225.28, 427/255.18, 225.27, 255.37, 255.393, 387, 427/551, 553, 557, 438/507, 509, 780-782, 438/787, 788, 789, 790, 783, 784
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- See application file for complete search history.

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30 Claims, 7 Drawing Sheets



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Harada et al. (43) **Pub. Date: Apr. 26, 2007**(54) **POROUS INSULATING FILM, METHOD FOR PRODUCING THE SAME, AND SEMICONDUCTOR DEVICE USING THE SAME**(30) **Foreign Application Priority Data**

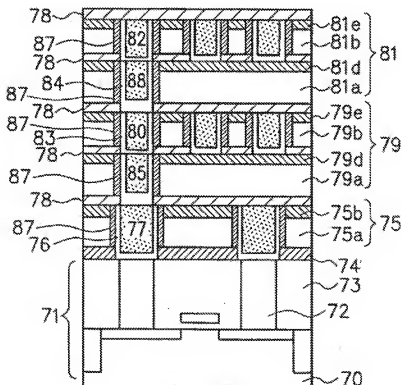
Nov. 28, 2003 (JP) 2003-400683

Publication Classification(76) **Inventors:** Yoshimichi Harada, Tokyo (JP);
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Hijoka, Tokyo (JP); Tsuneo Takeuchi,
Tokyo (JP)(51) **Int. Cl.**
H01L 21/31 (2006.01)
H01L 21/469 (2006.01)(52) **U.S. CL.** 438/796**Correspondence Address:****WHITHAM, CURTIS & CHRISTOFFERSON
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RESTON, VA 20190 (US)(21) **Appl. No.:** 10/580,606(22) **PCT Filed:** Nov. 29, 2004(86) **PCT No.:** PCT/JP04/17697

§ 371(c)(1),

(2), (4) **Date:** May 25, 2006(57) **ABSTRACT**

The present invention provides a process of producing a porous insulating film effective as an insulating film constituting a semiconductor device and a process of producing a porous insulating film having high adhesion to a semiconductor material, which is in contact with the upper and lower interfaces of the insulating film. Gas containing molecule vapor of at least one or more organic silica compounds, which have a cyclic silica skeleton in its molecule and have at least one or more unsaturated hydrocarbon groups bound with the cyclic silica skeleton is introduced into plasma to grow a porous insulating film on a semiconductor substrate.





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10702,092

METHOD FOR FORMING INSULATION FILM AND APPARATUS FOR FORMING INSULATION FILM

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